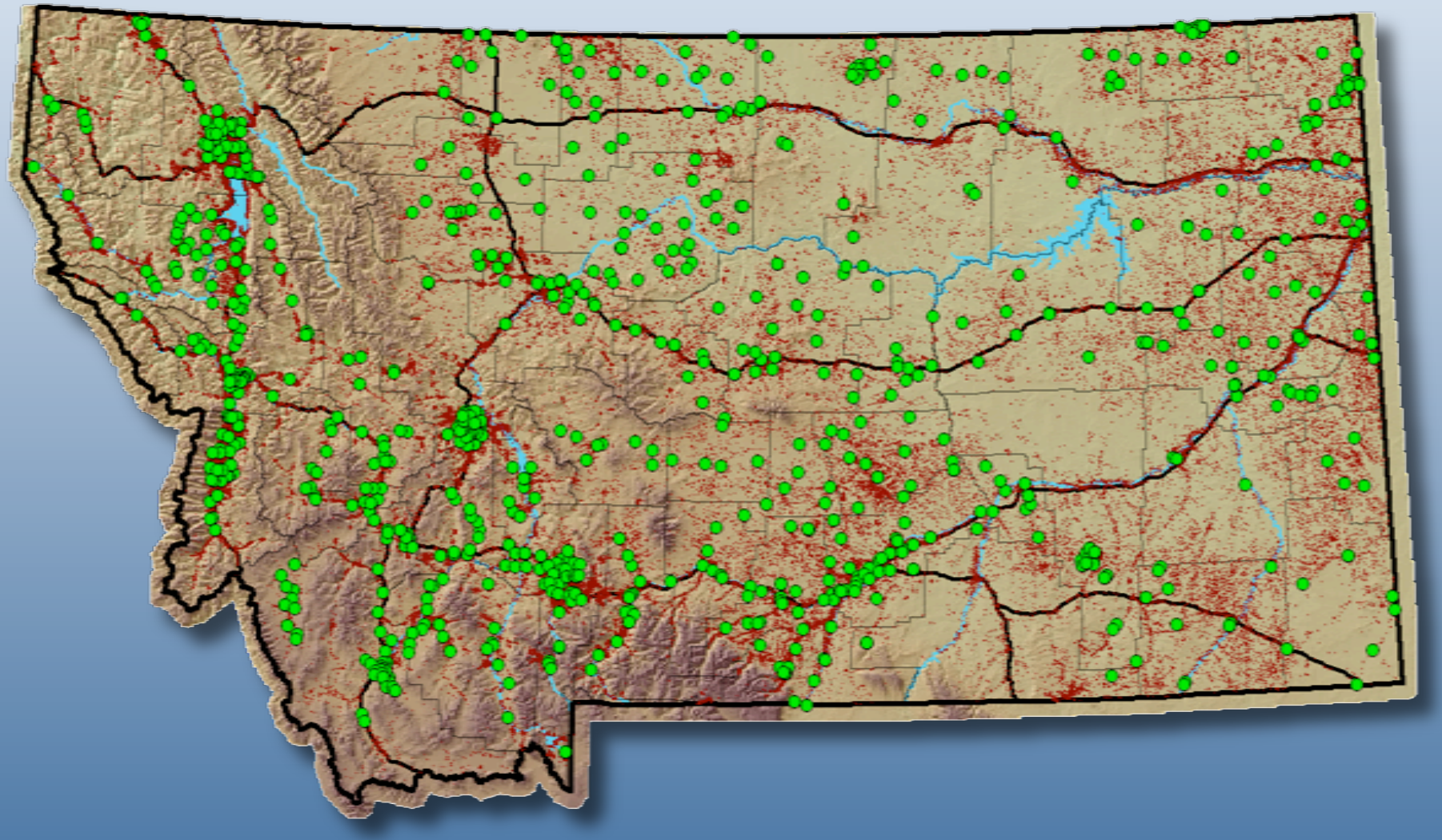
Wells and climate: hunting ENSO finding PDO?

Wells and climate in Montana

Thomas Patton

July 27-29, 2010

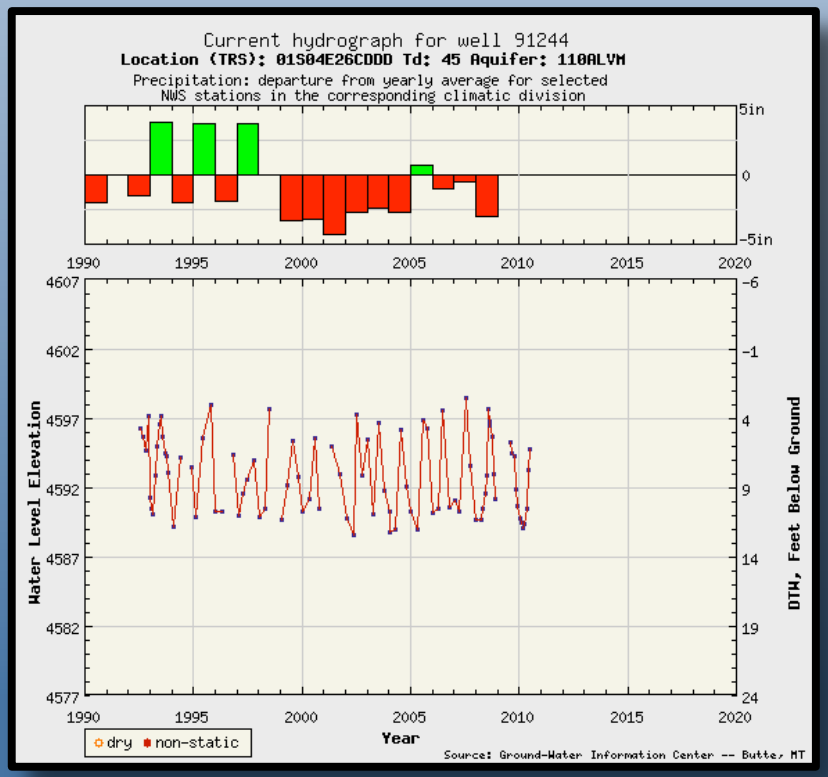
Ground-Water Monitoring



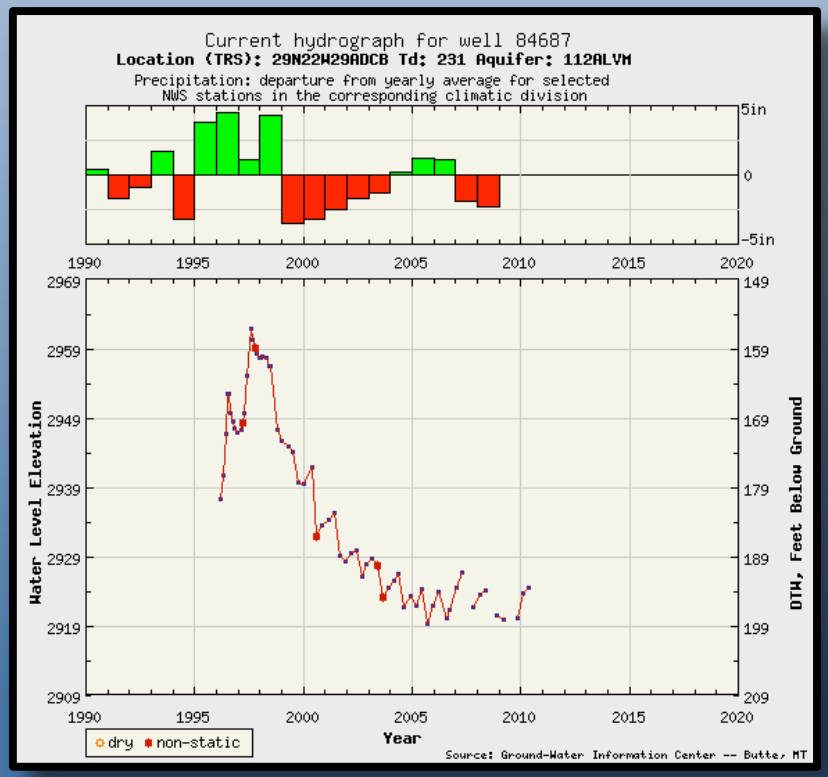
930 monitoring wells. About 30 percent (300+/-) dedicated or unused wells: 105 instrumented wells.

Climate Sensitive Wells

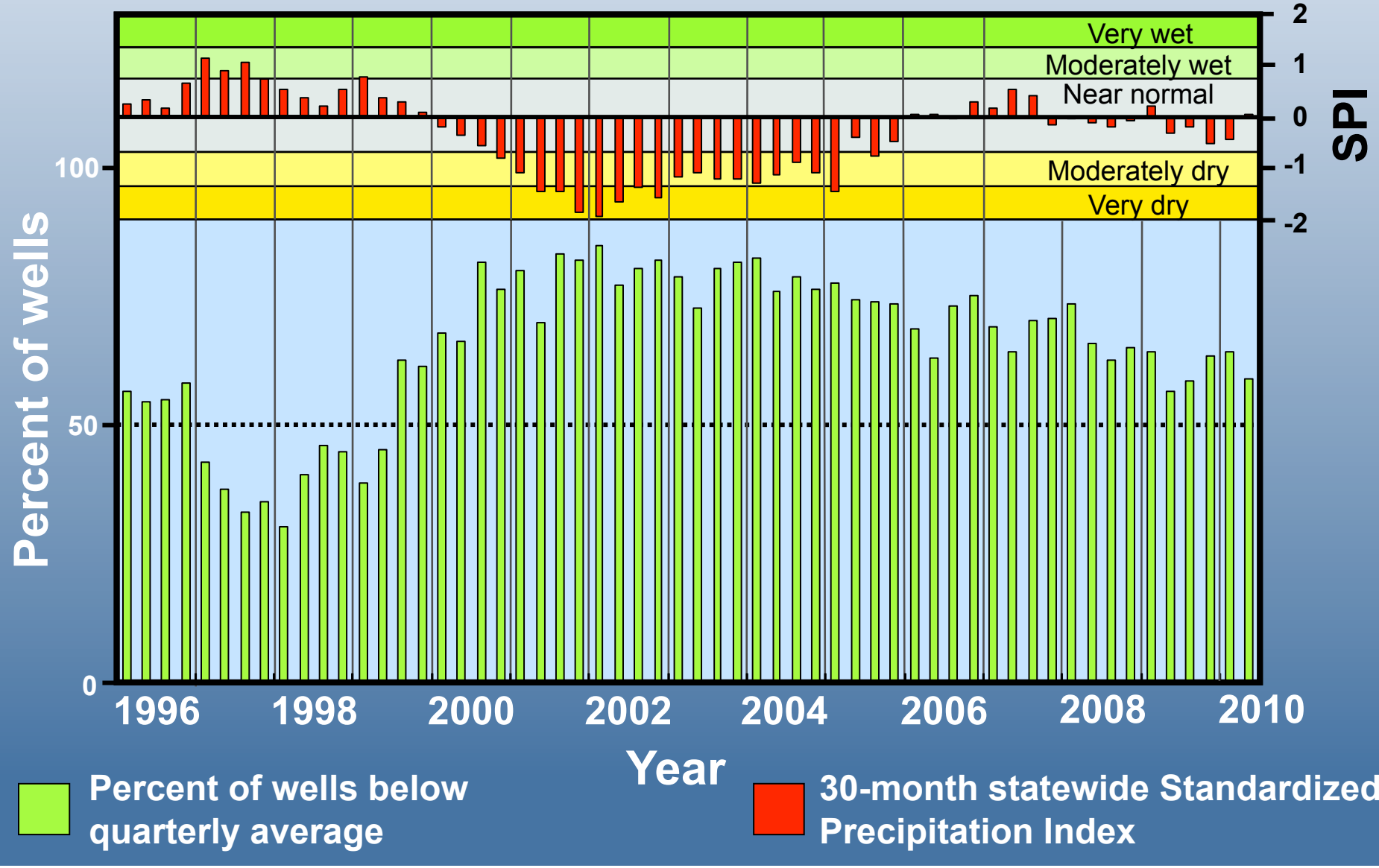
Wells that do not apparently respond to climate (~500)



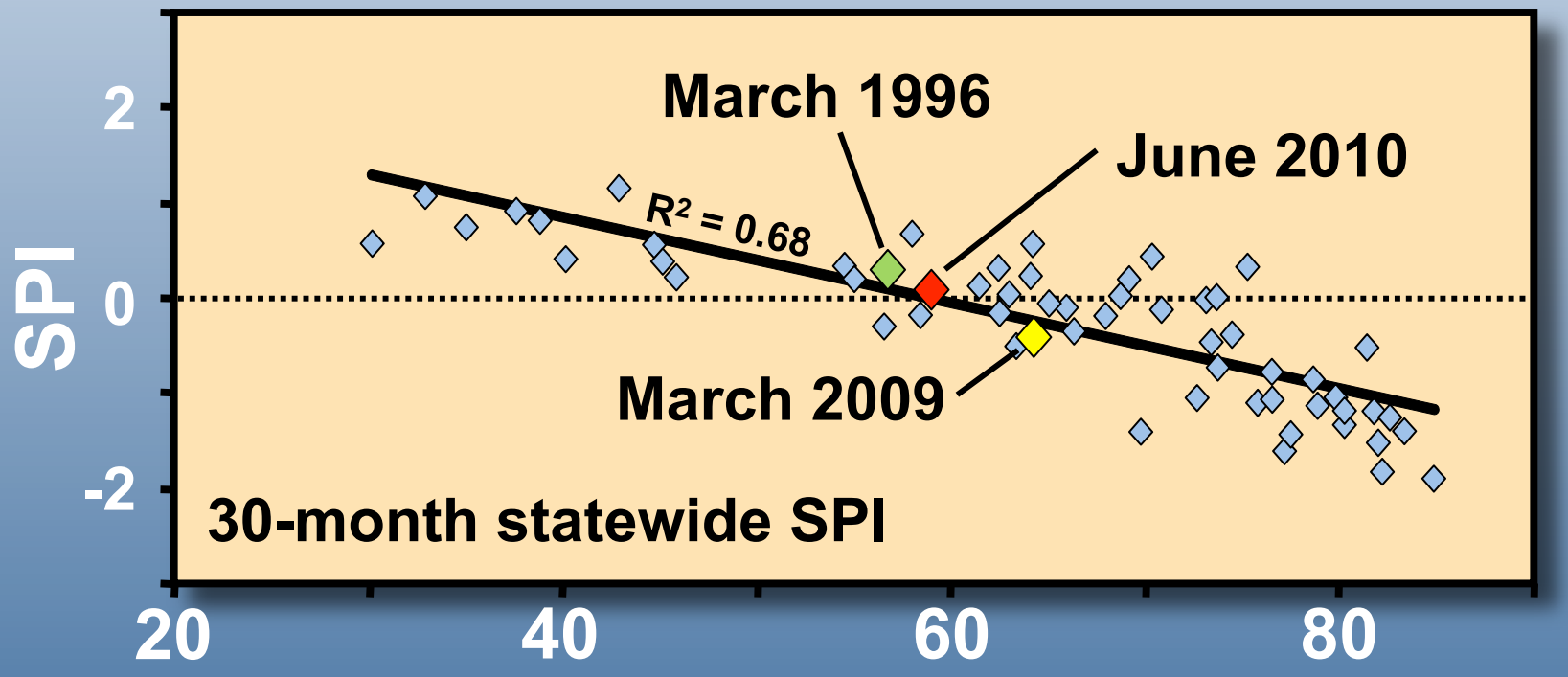
Wells with apparent long-term climate signature (~400)



Departures from quarterly average water level: climate sensitive wells

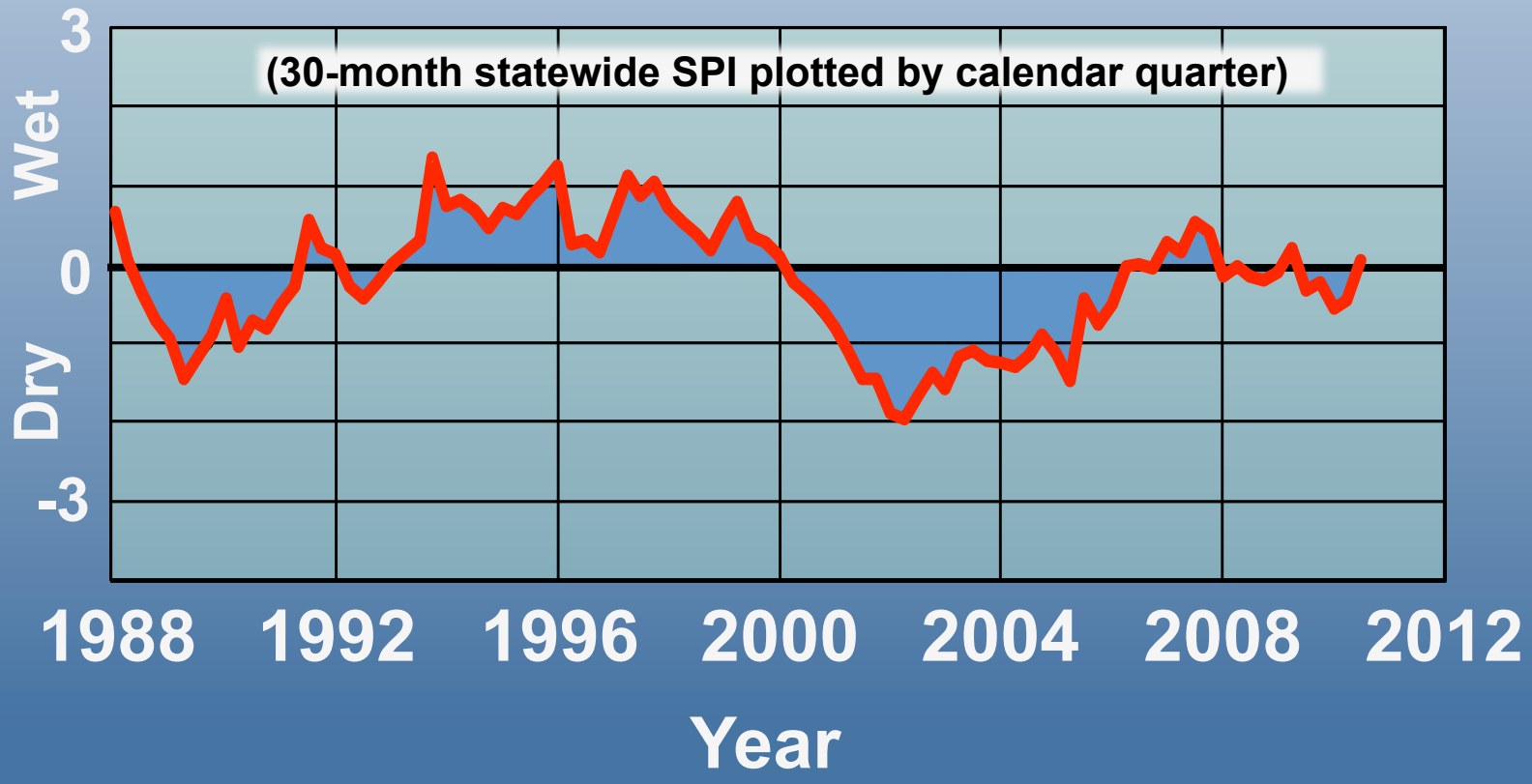


Statewide monitoring network: Percentage of wells below average and SPI: 1996-2010

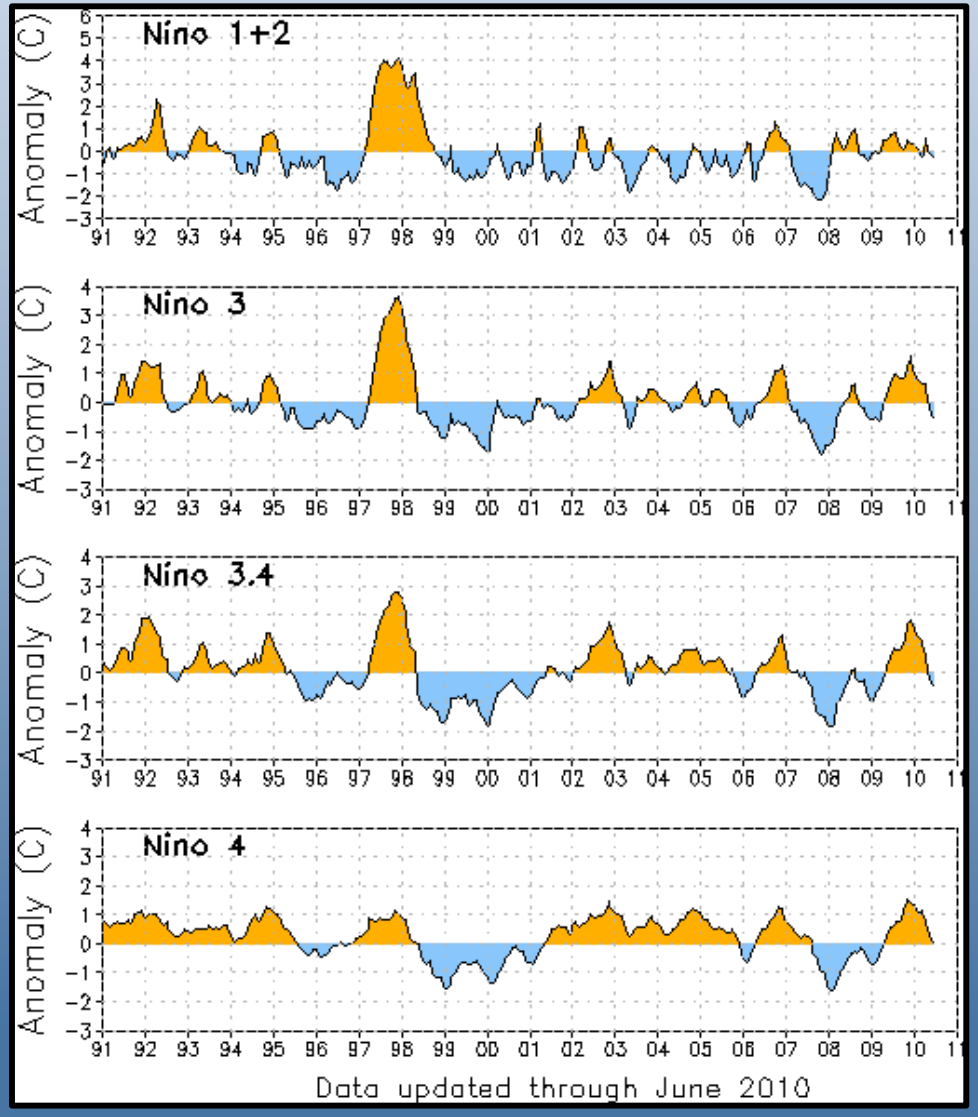


Cyclic precipitation departures

Precipitation varies from long-term averages at multiple time scales. The variability is complexly related to ocean/ atmospheric conditions monitored through indices such as **ENSO**, **PDO**, AMO, TAG, and others.



El Niño / La Niña and the Southern Oscillation (ENSO)

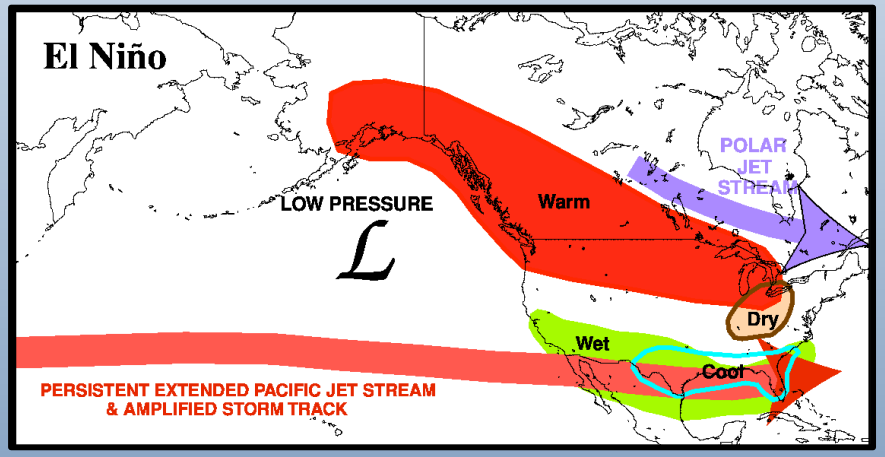


…years are categorized as El Niño or La Niña when water temperatures in the Niño 3.4 region of the tropical Pacific average approximately 0.5°C, above (El Niño) or below (La Niña) the mean temperature for three consecutive months…

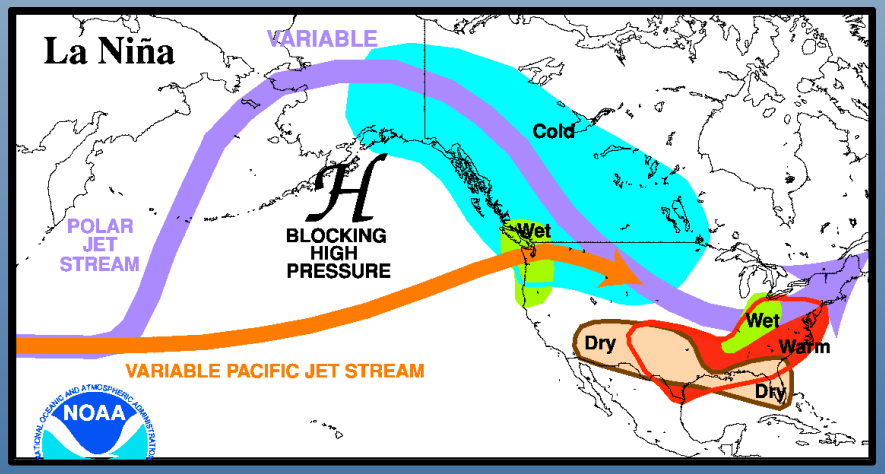
http://cses.washington.edu/cig/pnwc/compensopdo.shtml

Image: http://www.cpc.noaa.gov/products/CDB/Tropics/figt5.gif

El Niño / La Niña and the Southern Oscillation (ENSO)



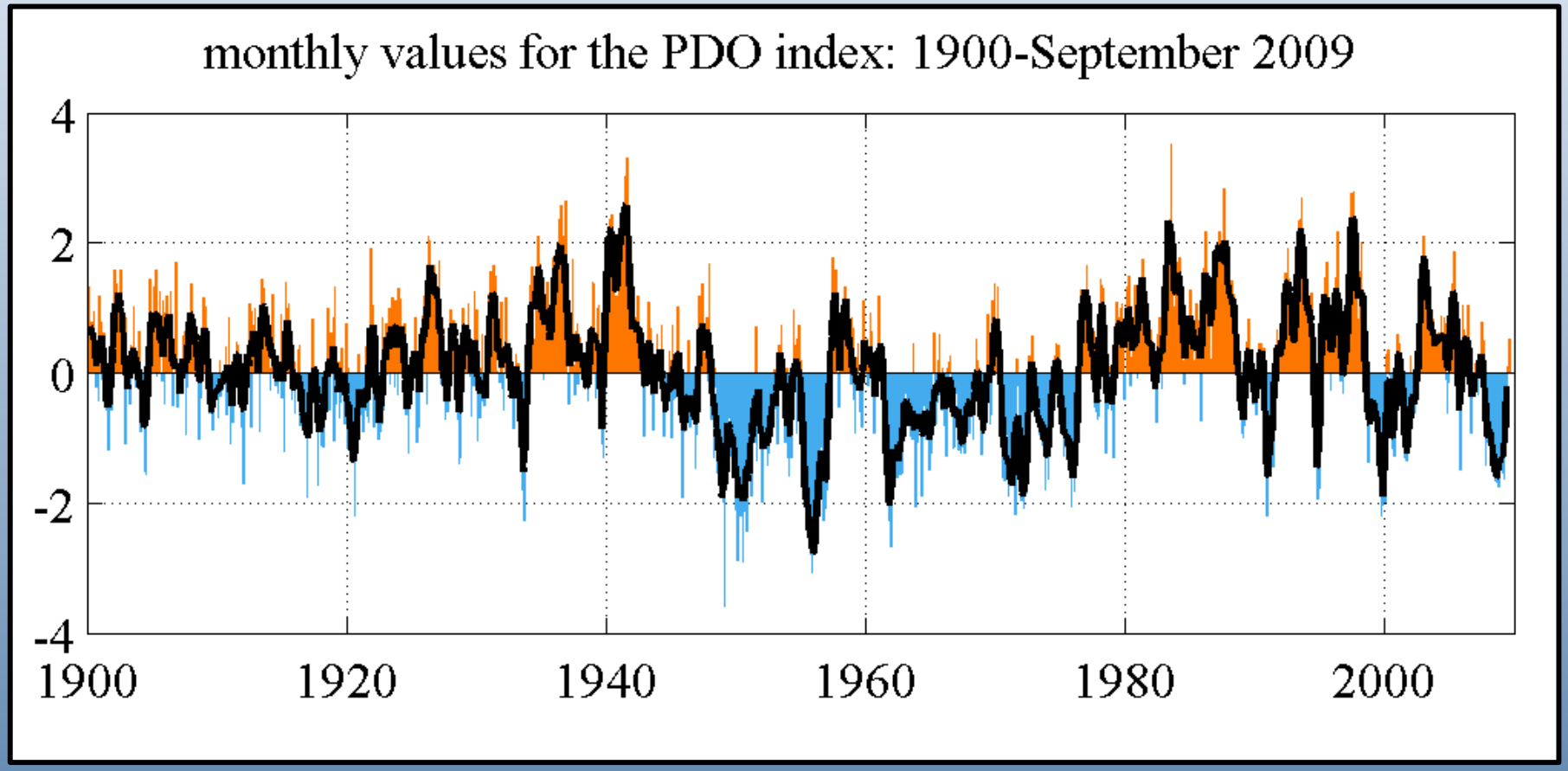
Typical Jan-March periods during moderate/strong El Niño episodes, feature a strong jet stream and storm track targeting the southern part of the United States.



Typical Jan-March periods during moderate/strong La Niña episodes, feature a variable Pacific jet stream and more northerly storm track. Conditions are colder and stormier than average across the North.

http://www.cpc.noaa.gov/products/analysis_monitoring/ensocycle/nawinter.shtml

Pacific Decadal Oscillation (PDO)

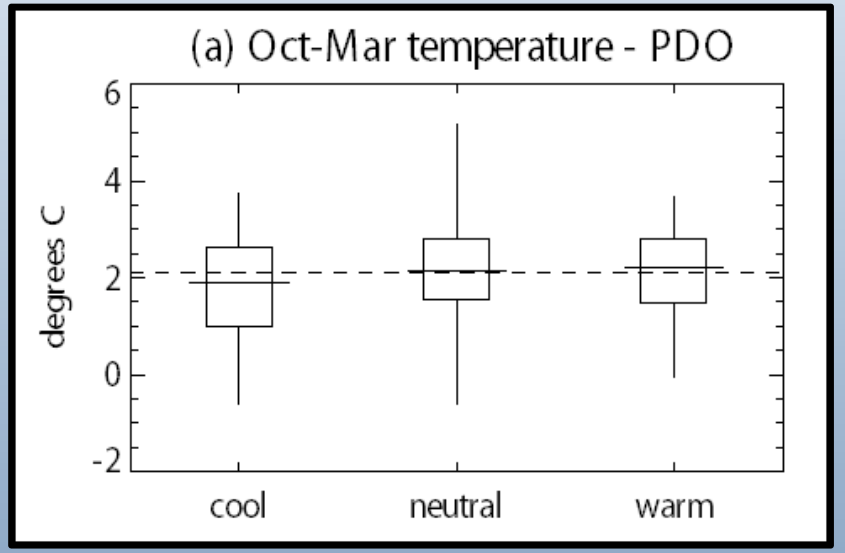


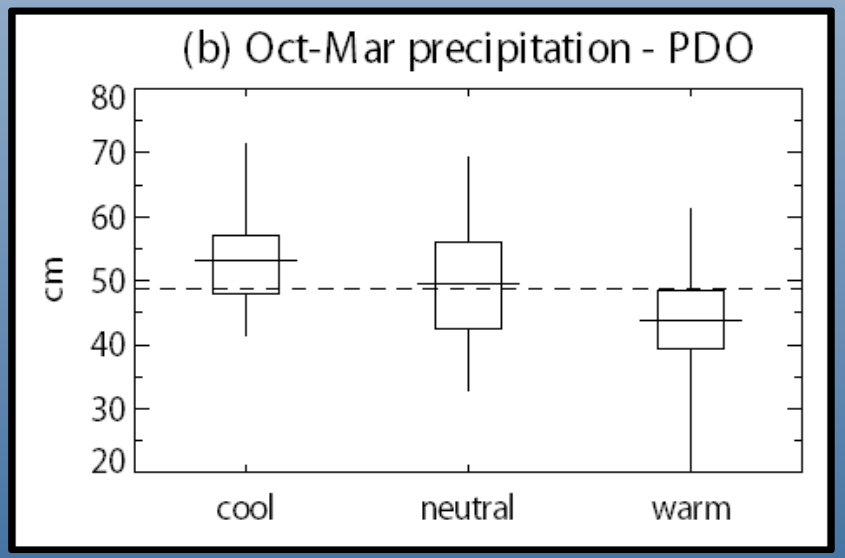
The leading principal component of monthly SST anomalies in the Pacific Ocean, north of 20N latitude. 20th century PDO "events" have persisted for 20-to-30 years.

http://jisao.washington.edu/pdo

Pacific Decadal Oscillation (PDO)

In the Pacific Northwest, cool **PDO-**phase winter-time temperatures tend to be lower, and precipitation amounts greater than during warm **PDO-**phases.





The **PDO** entered a cool phase in late 2007

http://cses.washington.edu/cig/pnwc/clvariability.shtml

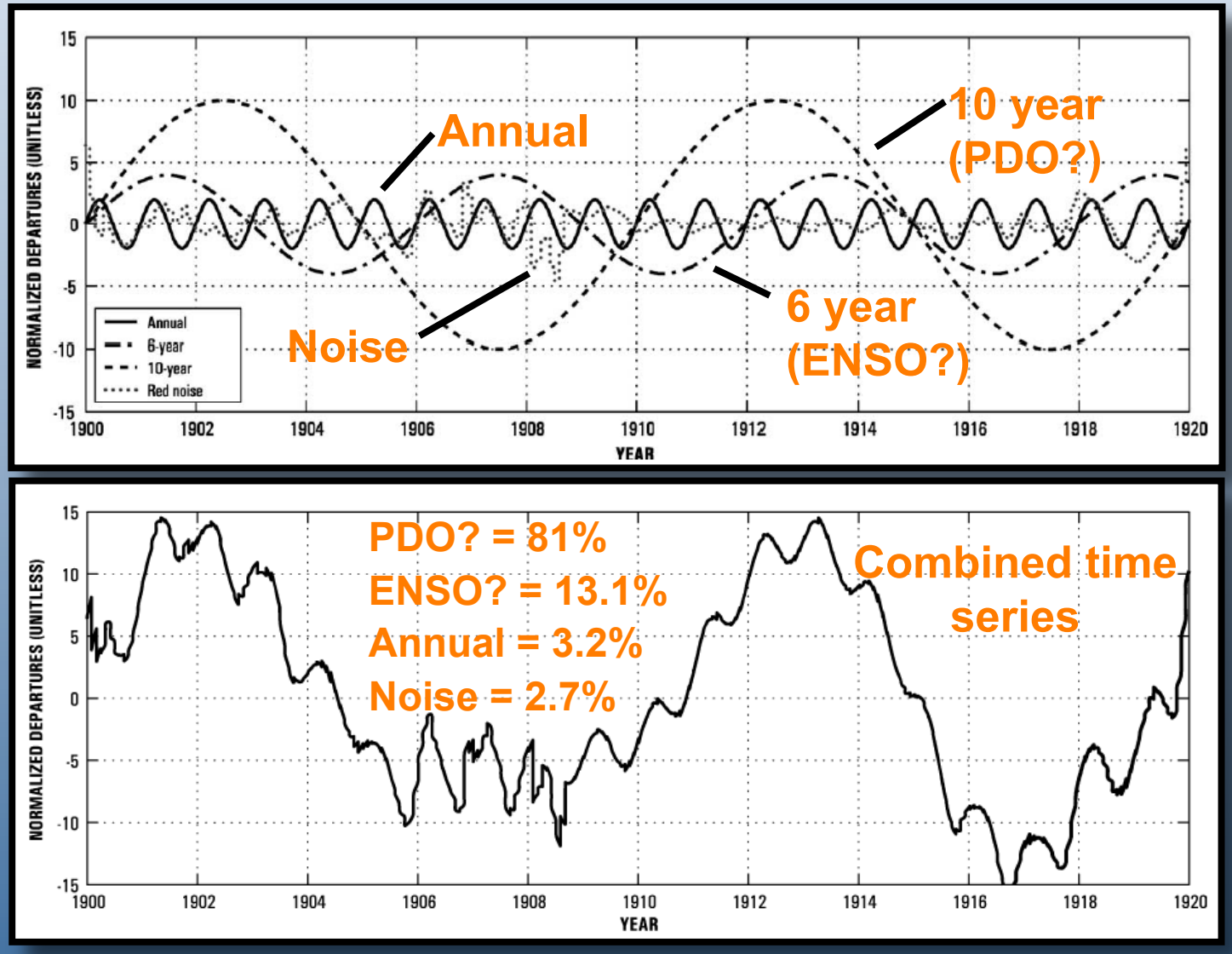
Climate forcing and hydrologic records

Hanson et.al., using spectral analysis of hydrologic records (including groundwater levels) from four basins in the southwestern United States found that:

- **Up to 80 percent of variations in reconstructed components can be correlated at corresponding time scales to variation in climate indices.**
- **PDO-like components (10-25 yr durations) were the largest contributors to cyclic hydrologic variability but ENSO signals (2-6 yr durations) were present in all basins.**

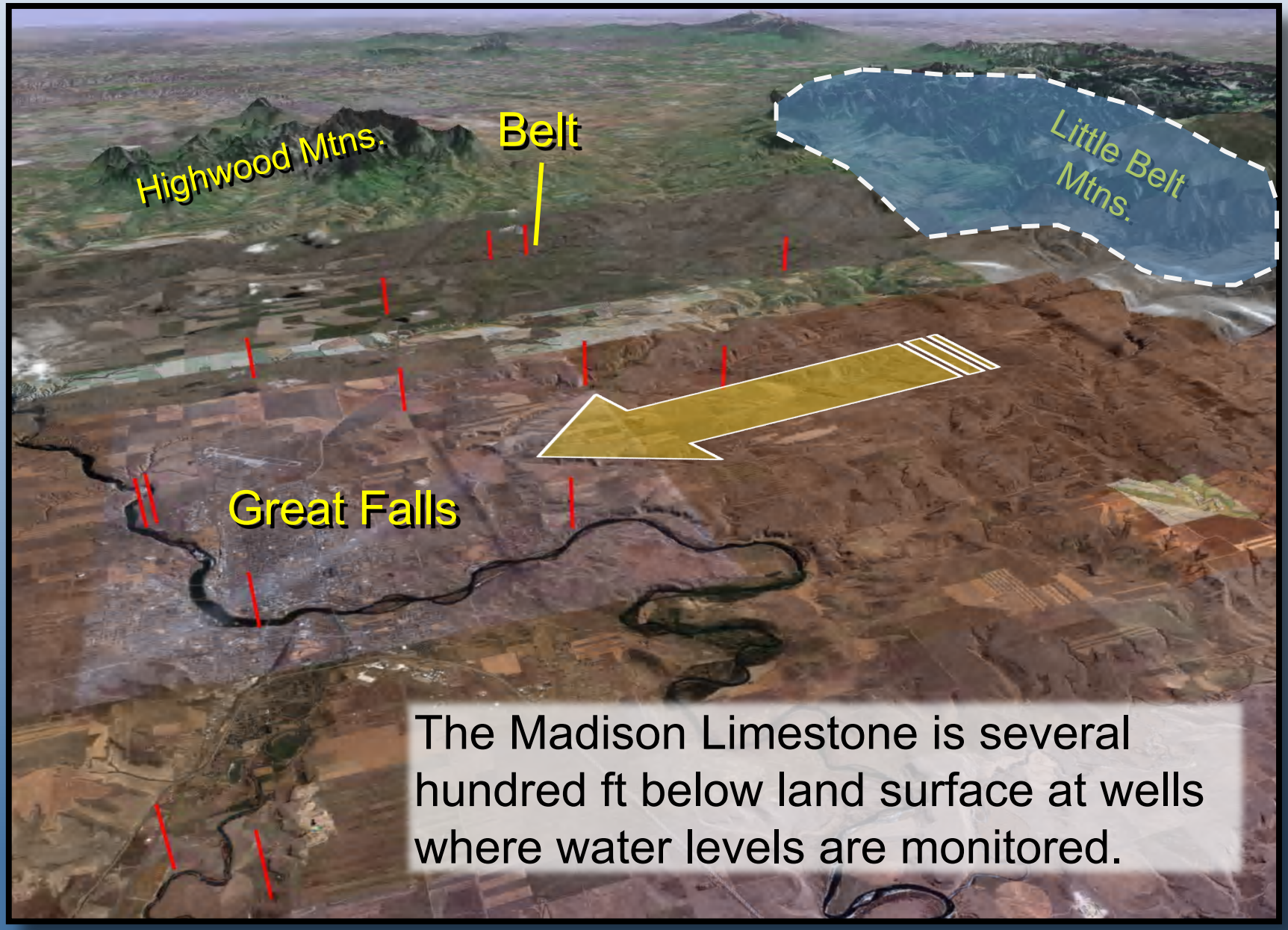
Hanson, R. T., Dettinger ,M. D. Newhouse, M. W., Relations between climatic variability and hydrologic time series from four alluvial basins across the southwestern United States, Hydrogeology Journal (2006) 14: pp 1122–1146

Climate forcing: synthetic example

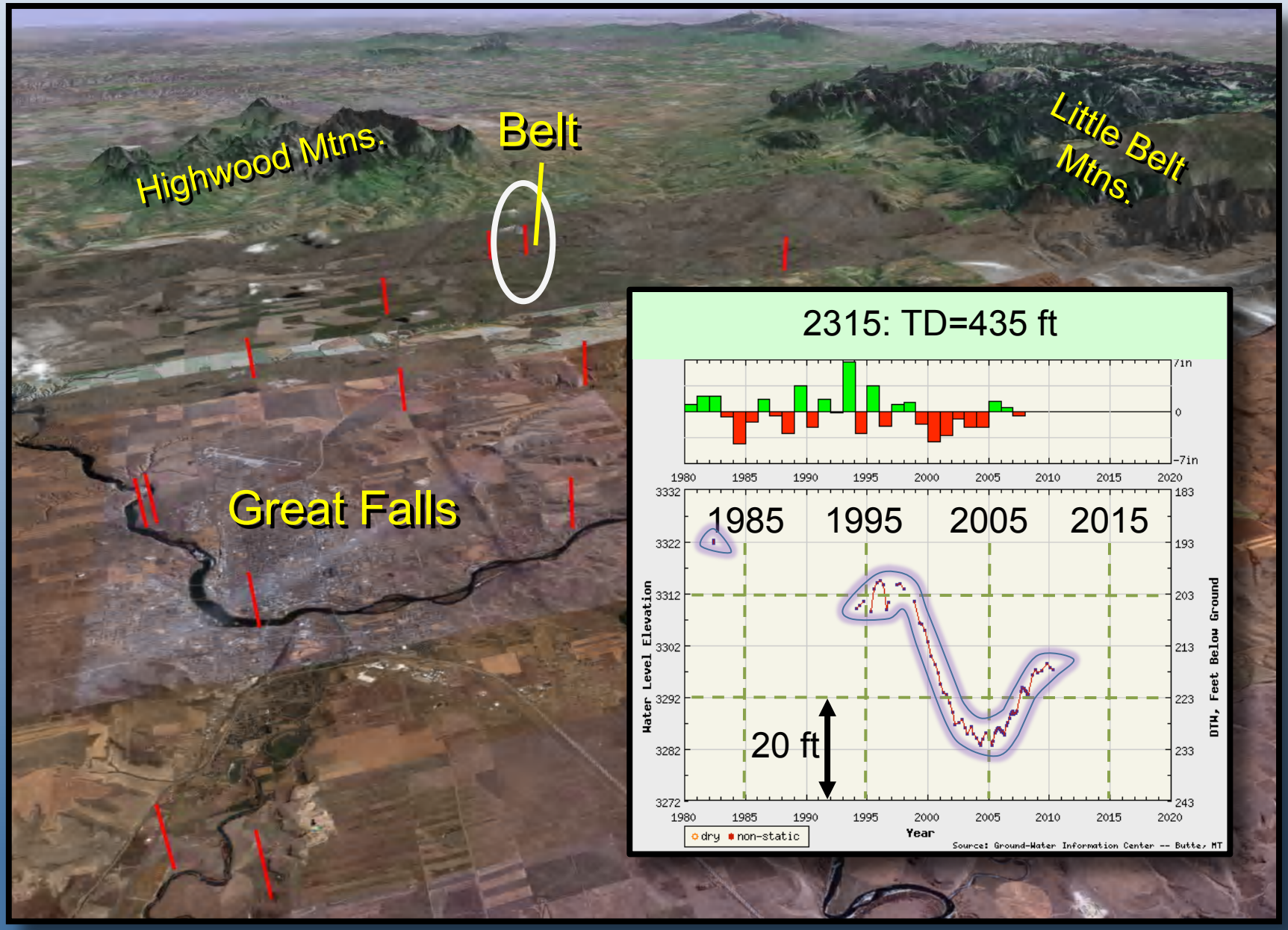


After Hanson, and others, 2003

Great Falls area



Madison Limestone hydrographs



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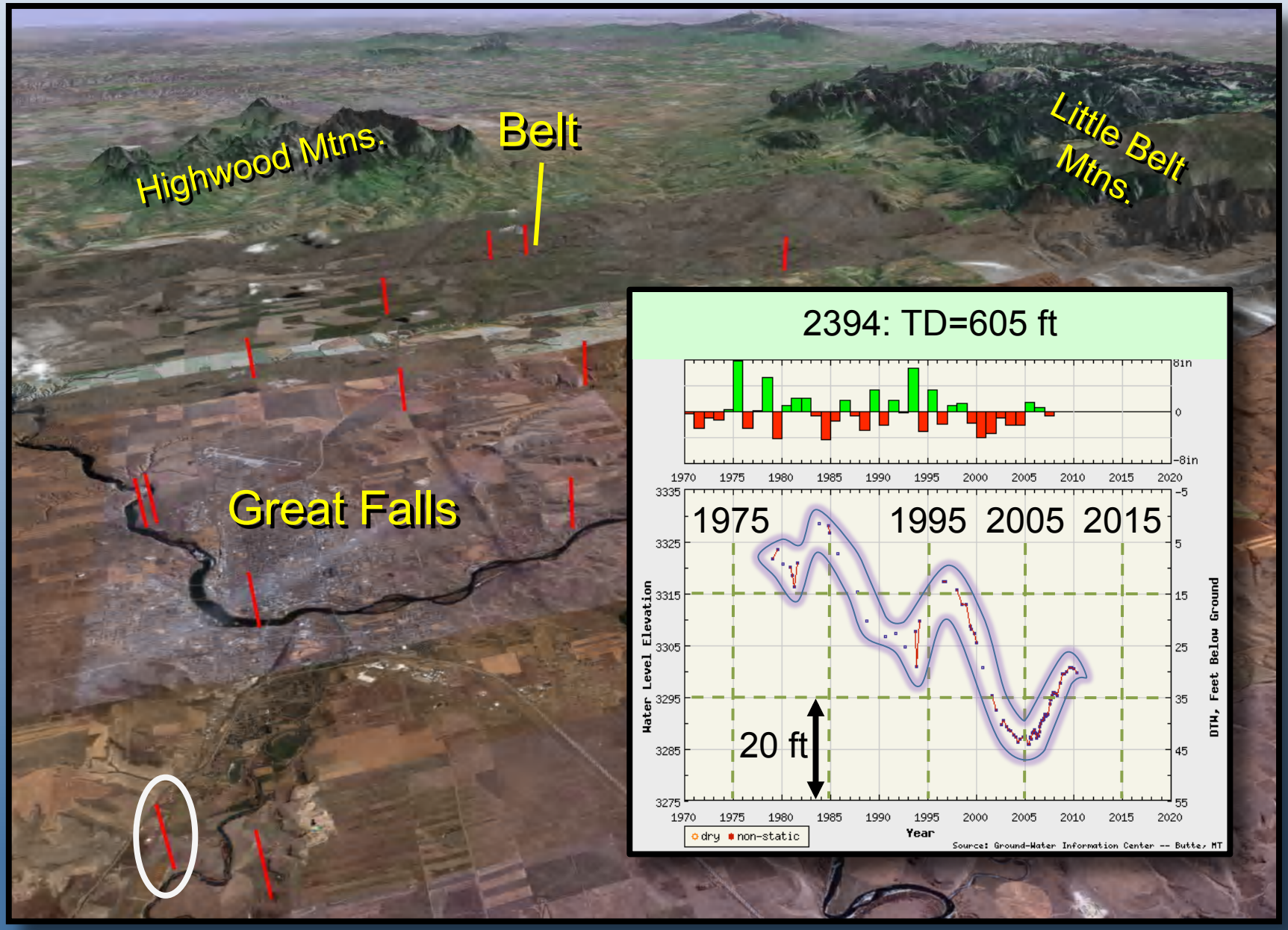
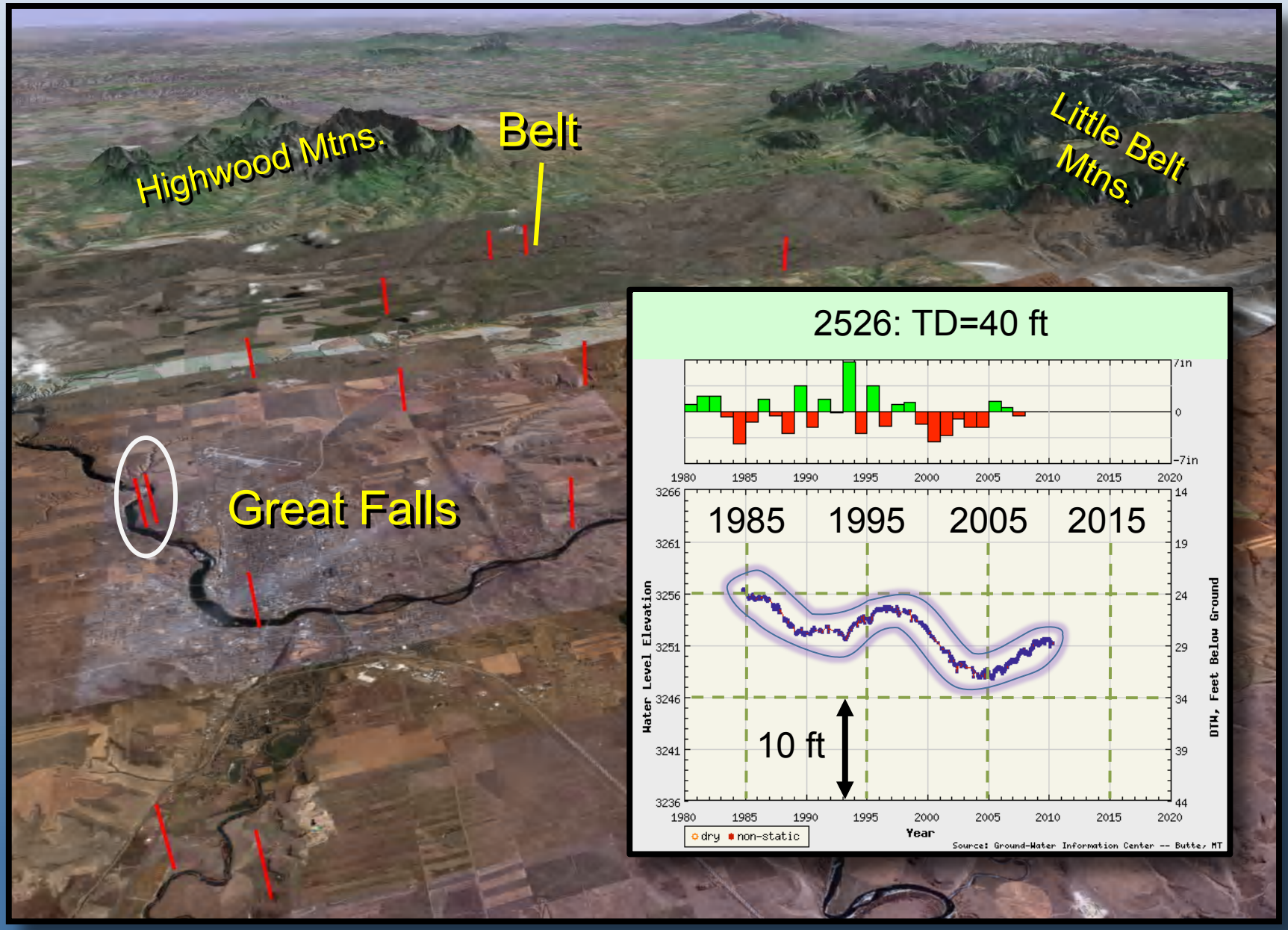


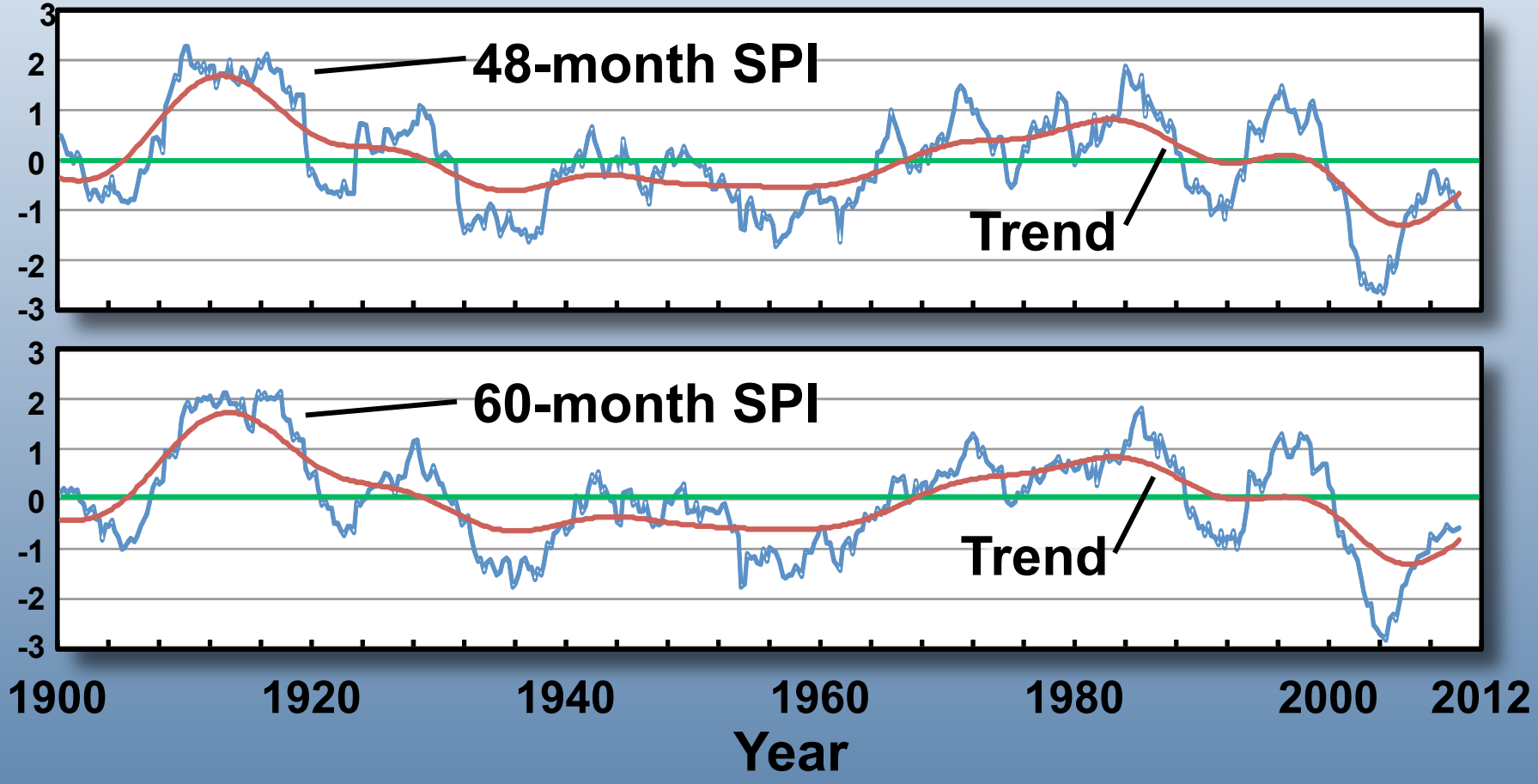
Madison Limestone hydrographs



Hydrograph from well 2526

Total depth 40 ft: completed within the Kootenai Formation in the Giant Springs discharge system

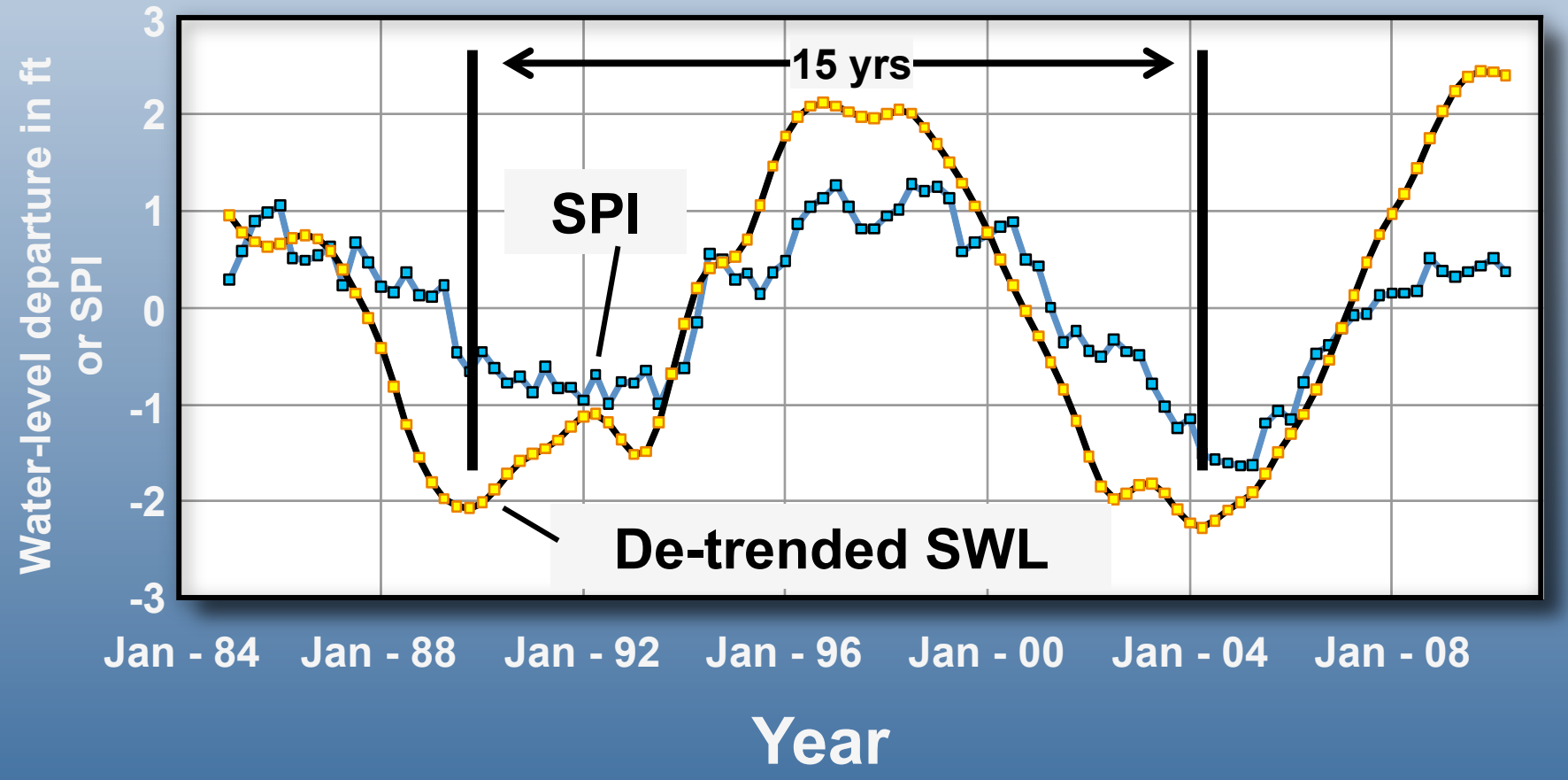
48 and 60-month SW SPI's



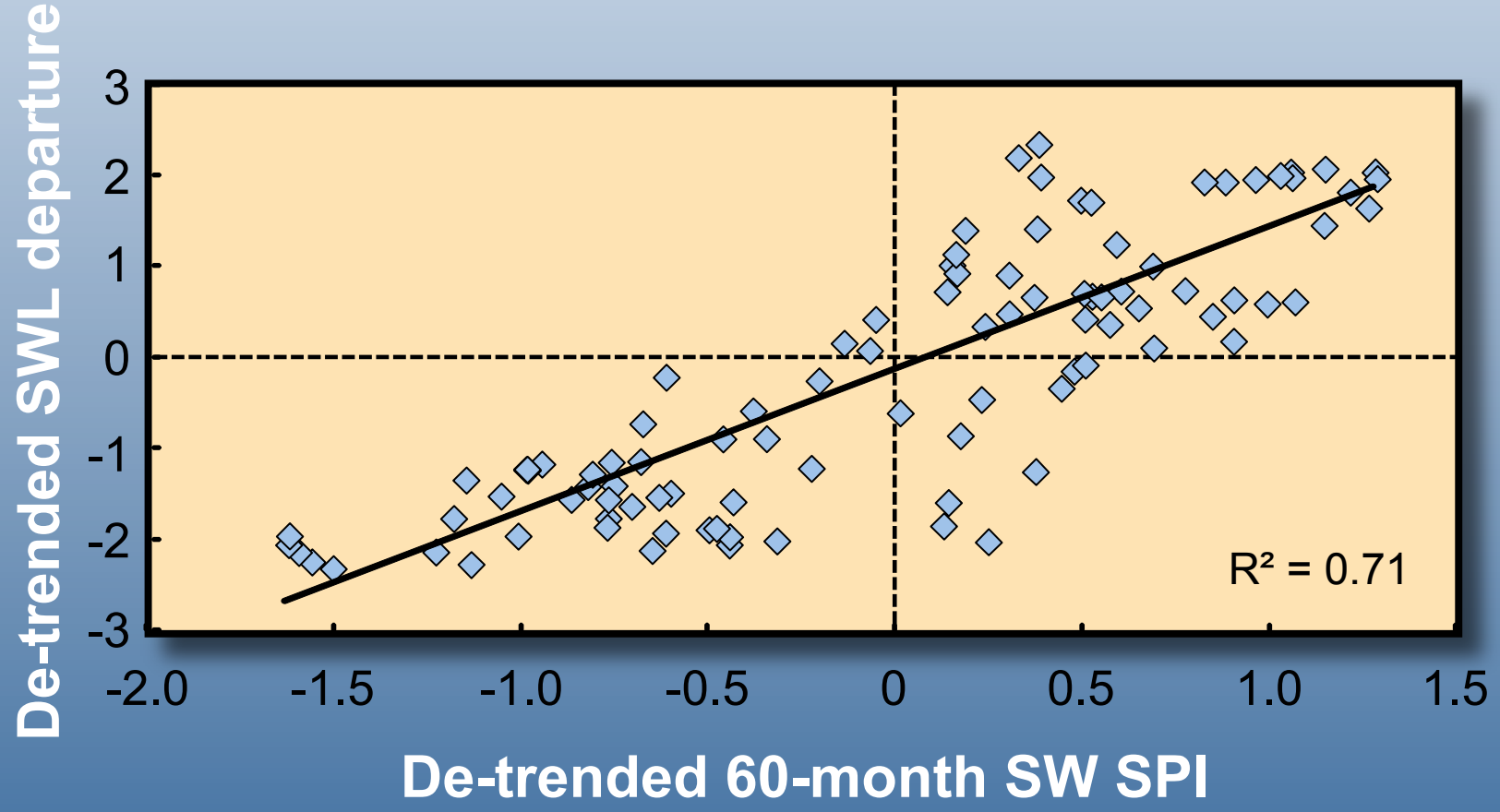
Since about 1980, trends in the 48- and 60-month SPI's have been towards dryer conditions.

Hydrograph from well 2526

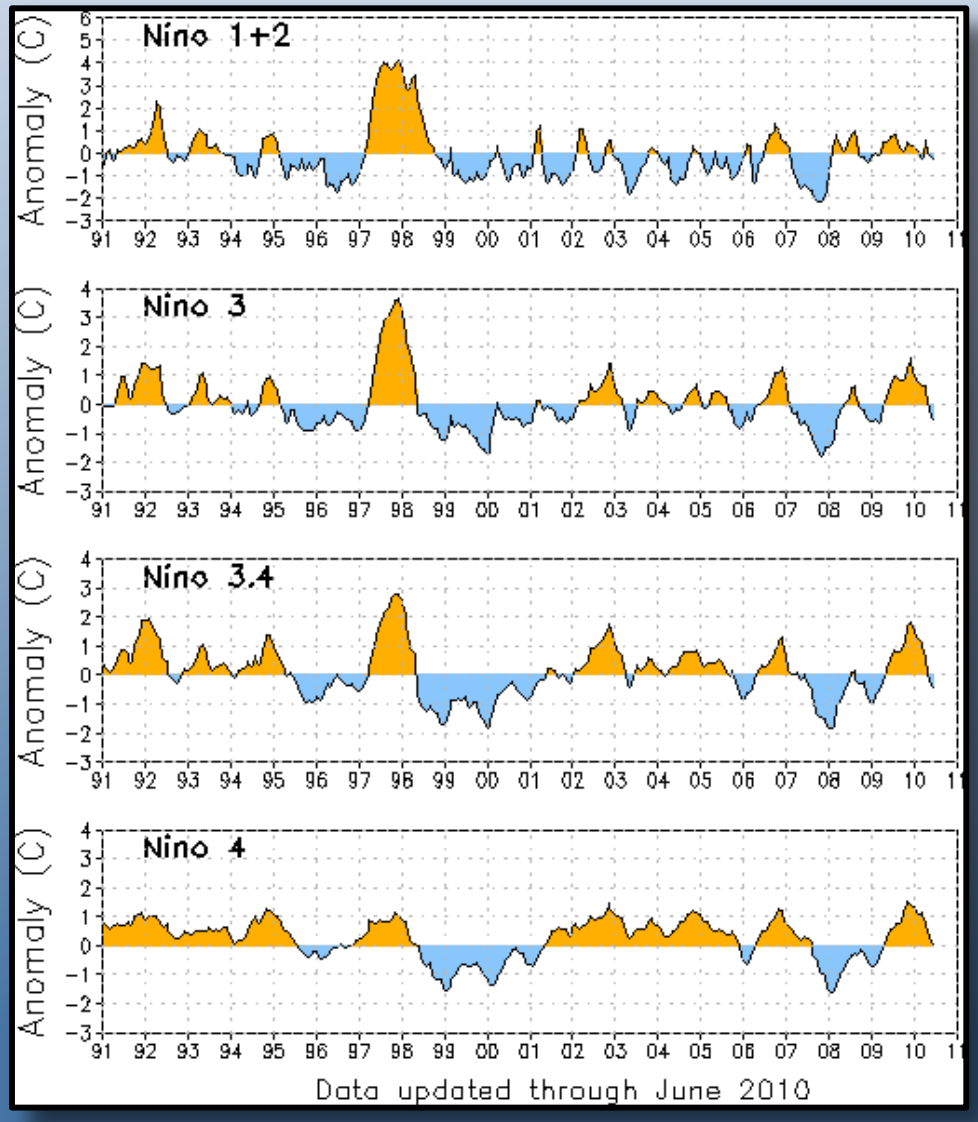
De-trended climate signal(?) and de-trended 60-month Southwestern Climate Division SPI



De-trended SWL departure and 60-month SW SPI



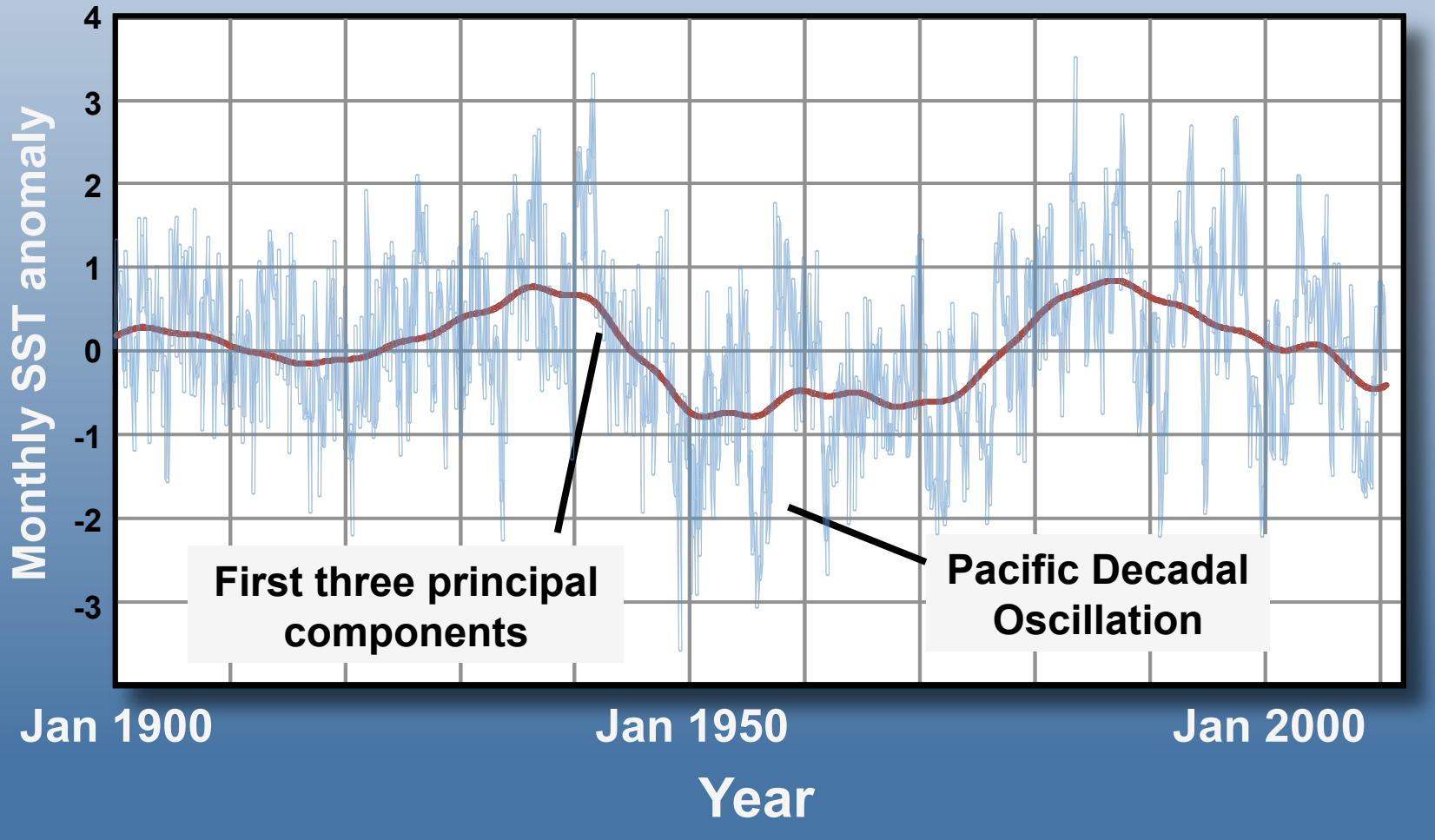
Discussion: ENSO



The 15-yr period in the long-term climate component extracted from the hydrograph does not match the 1.5- to 6-yr cycle in the ENSO index. ENSO signals may be reflected in residuals of similar frequency extracted from the hydrograph.

Pacific Decadal Oscillation

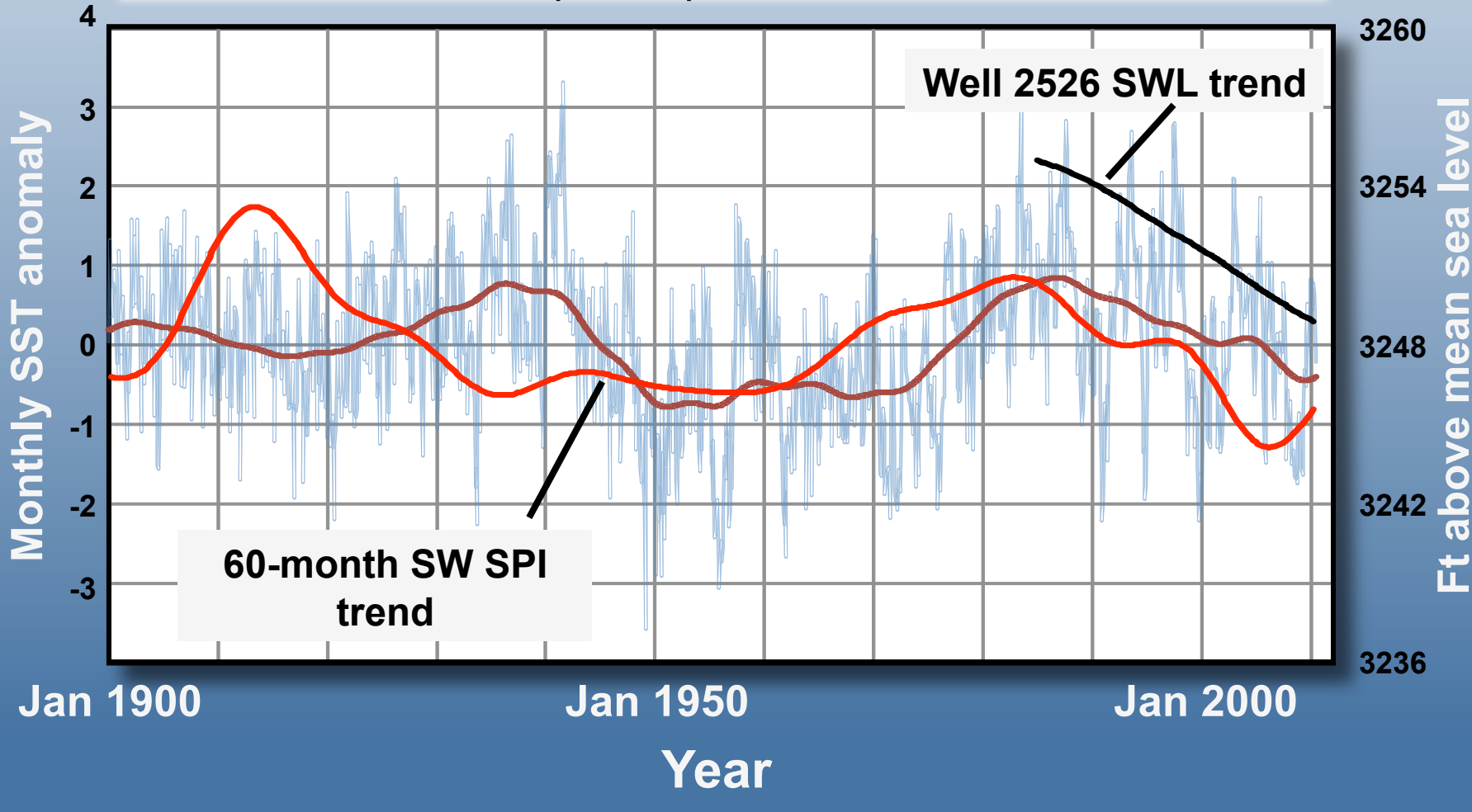
Apparent long-term cycles in the PDO, roughly coincident with its warm/cool phases, are shown by the smoothed trend line. The smoothed line is the first three principal components of a SVD decomposition performed by Caterpillar SSA.



Pacific Decadal Oscillation

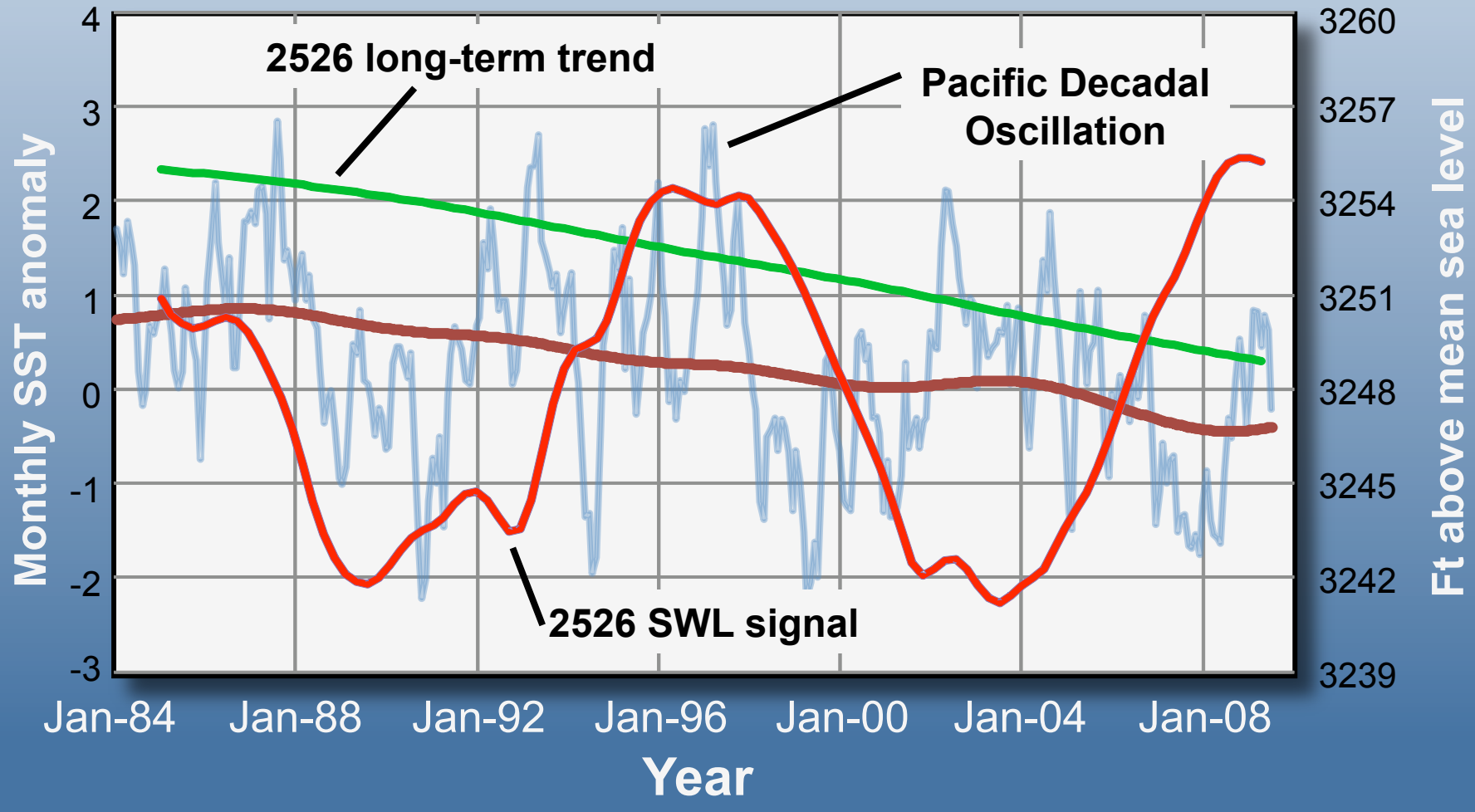
The long-term downward trend in water levels from well 2526 follows the current downward trend in the PDO.

The current drying-trend in the 60-month SPI also aligns with the PDO, but is out of phase prior to about 1970.



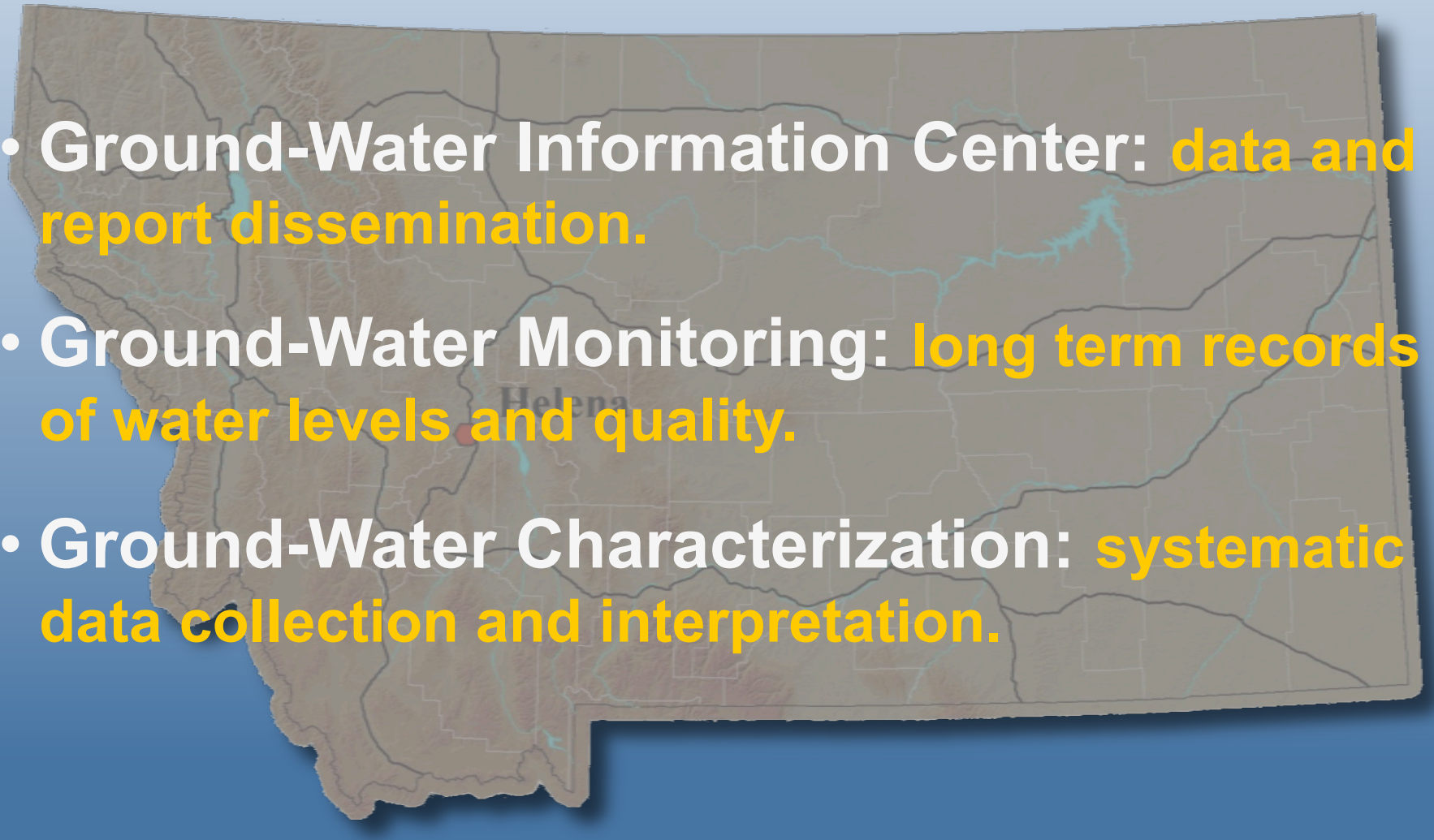
Pacific Decadal Oscillation

Although the long-term trends are in a similar direction, the 15-yr climate signal in well 2526 does not appear to match similar-frequency fluctuations in the PDO.



Brought to you by:

Montana Ground-Water Assessment



- Ground-Water Information Center: data and report dissemination.
- Ground-Water Monitoring: long term records of water levels and quality.
- Ground-Water Characterization: systematic data collection and interpretation.

Montana Ground-Water Assessment

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Montana Bureau of Mines and Geology
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